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The means in the above tables were taken in two ways: (i.) the simple mean, the result for each star being considered of equal weight; (ii.) the weighted mean, the weight being equal to the number of photographs on which the distorted images occur. The results are shown in the following table:

Limits of Distance.	Mean Distance from Centre.	No. of Stars.	Weight.	Mean Distortion. (i.)	Mean Distortion. (ii.)	Mean Discordance after Correction for Distortion.	Mean Discordance (Uncorrected).
′ ′	′			″	″	″	″
45–50	47·5	38	130	+·014	+·005	±·12	·12
50–55	52·5	29	98	−·029	−·044	·14	·15
55–60	57·5	32	93	−·106	−·083	·21	·20
60–65	61·6	14	26	−·181	−·166	·21	·27
65–75	70·0	12	36	−·262	−·354	·25	·34

The table given above shows:

(i.) At greater distances than 55′ from the centre star-images are in the mean sensibly distorted inwards.

(ii.) The amount of this distortion is subject to such variations depending on the magnitude of the star and exposure of the photograph that very little is gained by applying this mean correction. The means irrespective of sign of Table I. given in the last column of Table II. are sensibly the same as the discordances obtained after applying the mean distortion.

(iii.) The falling-off in accuracy due to photographic distortion is very marked beyond 55′ from the centre.

In the reduction of the *Eros* photographs no correction is being applied for distortion, and reference stars at greater distances than 55′ from the centre of the plate are not used except in one or two instances, where the number of stars is very small.

Magnetic Disturbances as recorded at the Royal Observatory, Greenwich, and their Association with Sun-spots. Third Paper. By E. Walter Maunder.

7. *Diurnal Inequality in Magnetic Disturbances.*

An examination of the two catalogues of magnetic disturbances contained in my first and second papers respectively (*Monthly Notices*, vol. lxv. pp. 2–34, and 538–559) shows a marked tendency in the selected times of commencement to favour certain hours of the Greenwich day. Table XIV. brings this tendency into prominence, and with it a curious difference between the catalogue in Table I. of the years 1882 to 1903 and that in Table IX. of the years 1848 to 1881.

Both catalogues agree in giving the commencement of at least

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three out of every four disturbances as falling between noon and midnight, and hardly one fourth between midnight and noon. Both agree also as to a fairly even distribution of the disturbances through these morning hours—0 hours to 11 hours inclusive. But there is a striking difference between the two catalogues as to the distribution during the evening hours, 12 hours to 23 hours. For whilst Table I. gives a very sharply defined maximum at 13 hours, Table IX. rises, with a regularity which precludes the possibility of accident, to a most unmistakable maximum at 18 hours.

It is not to be supposed that this difference indicates any change in the actual disturbances themselves taking place about the years 1881 or 1882; it is merely a question of a systematic difference in the taking out of the times of commencement.

Disturbances may be divided into two classes according to the character of their commencement. All very great storms and not a few minor ones begin with the characteristic sharp instantaneous impulse indicated by the letter "S" in Table I. These constitute the first class, and there is no ambiguity about the times of their commencement, except in the cases of a few long-continued storms, showing more than one of such sharp movements following a period of rest.

But there may be considerable ambiguity about the time of commencement of the second class, the more numerous but usually less intense disturbances where no such sharp initial movement is shown. These begin in many ways: sometimes by rapid but slight "fluctuations," sometimes by a single "wave," sometimes by a succession of small movements of varying character and amplitude.

Here there is room for some uncertainty in fixing the time of commencement. It is not an uncertainty which has any serious effect upon the interval between successive disturbances, nor in any case is it sufficiently large seriously to affect the relation of disturbances "in sequence."

TABLE XIV.

Hourly Distribution of Magnetic Disturbances.

Greenwich Civil Time.	1848 to 1881.	1882 to 1903.			1848 to 1903.			
		All.	Commencement.		Great.	Active.	Moderate.	
			Sharp.	Gradual.				
h								
0	12	5	1	4	1	6	10	17
1	11	3	2	1	3	5	6	14
2	8	6	2	4	2	7	5	14
3	7	10	6	4	2	8	7	17
4	5	5	3	2	2	5	3	10
5	6	5	3	2	2	5	4	11
6	8	8	3	5	2	6	8	16
7	7	2	0	2	0	3	6	9

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Greenwich Civil Time.	1848 to 1881.	1882 to 1903.			1848 to 1903.			
		All.	Commencement.		Great.	Active.	Moderate.	
h			Sharp.	Gradual.				
8	6	9	6	3	4	5	6	15
9	7	4	2	2	2	7	2	11
10	8	7	4	3	4	5	6	15
11	11	5	2	3	3	10	3	16
12	12	24	1	23	2	18	16	36
13	22	40	4	36	6	18	38	62
14	26	29	8	21	8	15	32	55
15	31	20	5	15	1	19	31	51
16	39	20	5	15	1	26	32	59
17	42	9	2	7	4	19	28	51
18	45	15	2	13	3	20	37	60
19	43	16	4	12	6	16	37	59
20	26	10	4	6	2	13	21	36
21	24	9	0	9	0	10	23	33
22	15	9	5	4	2	10	12	24
23	24	6	3	3	2	12	16	30
0–11	96	69	34	35	27	62	66	
12–23	349	207	43	164	37	206	323	
Total...	445	276	77	199	64	268	389	

But if the point to be determined is not the *interval* between two disturbances, but the precise hour at which each commences, the problem is rendered difficult by the strongly marked tendency of minor magnetic movements to vary in character with the local time.

This tendency may be illustrated by Table XV., in which the small isolated "wave" movements of the declination magnet at Greenwich for the year 1894 February 1 to 1895 January 31 are arranged according to the civil hour of the beginning of the swing. It will be seen at once how strongly marked is the tendency for eastward waves to take place about 18 hours or 19 hours; for westerly waves to occur in the hours immediately after midnight. The movements represented in this table are those given in the "Notes" of the Greenwich volumes; the more considerable movements represented in the plates are therefore not included.

An inspection of Table XIV. shows how strongly the times of the smaller disturbances are affected by this diurnal inequality.

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The "great" disturbances are distributed throughout the 24 hours with almost complete impartiality. So, too, are the disturbances which open with the characteristic sharp to-and-fro impulse. But less than one in four of the "active," hardly one in six of the "moderate," have their beginnings between midnight and noon; and those of gradual commencement show the same unequal tendency.

Table XV.

Hourly Distribution of Small Wave-movements, 1894–5.

Greenwich Civil Time.	Declination.		Horizontal Force.		Greenwich Civil Time.	Declination.		Horizontal Force.	
h	Westerly.	Easterly.	Increase.	Decrease.	h	Westerly.	Easterly.	Increase.	Decrease.
0	14	6	13	1	12	1	1	2	1
1	12	2	7	1	13		2	3	3
2	11	2	7	1	14		3	3	2
3	10	2	4	3	15		4	3	4
4	3		2	1	16	2	9	8	8
5	4		1		17		20	9	8
6	2		1	1	18		29	11	9
7	1			1	19		21	14	3
8	2				20		19	11	5
9					21	2	16	16	4
10					22	3	18	19	2
11					23	4	8	8	

If our magnetic disturbances are excited from without, then when any large number of them are taken it is natural to expect that they will be found distributed indifferently to the local time at any one station. The "sharp" movements are, as far as we know, simultaneous over the whole earth, and hence are independent of local time. So, too, with storms of the first rank: their times of commencement are indifferent to local time. But the phases of the after-development of a disturbance are not so independent, and give clear indications of their connexion with the presentation of the observing station with respect to the Sun; or, in other words, with local time. With the less intense disturbances therefore, the phases connected with the local time are of greater relative distinctness, and the times when the phases of diurnal disturbance are most strongly marked are naturally most often taken as the times of commencement. These times are: first, about six o'clock in the evening, when the easterly "wave" in declination is most frequent; and second, shortly after noon, when a westerly movement made up of small "fluctuations" is apt to set in. In Table IX.—the catalogue of the disturbances from 1848 to 1881—the former phase had the

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most effect, for the times were determined by reference to the original photographic registers, and the sheets for the days preceding and following the disturbances were examined, and the most striking change was taken as the point of commencement. In Table I.—the catalogue of the disturbances from 1882 to 1903—the times were taken from the reproductions of the registers given in the plates of the Greenwich volumes, and these in the majority of cases began with Greenwich noon; hence the fluctuations of the early afternoon more frequently caught the attention. A reference to the original registers showed that, had the times for these later years been taken out from them, the same massing of disturbances around 18 hours civil time would have been seen in the catalogue of Table I. as in that of Table IX. For, though so many of our magnetic disturbances are world-wide, and though the sharp impulse with which not a few commence occurs, so far as we know, at the same minute of absolute time the whole world over, yet these disturbances often differ much at different stations in intensity, in character, and in the absolute times at which the subordinate phases develop. So far as Greenwich, at least, is concerned, there is a strong tendency for certain well-marked phases to recur with the same hours of local time as Tables XIV. and XV. indicate; the most obvious of these "local time movements" occurring between noon and midnight, and culminating near six o'clock in the evening.

It is obvious that stream-lines from the Sun, such as the interval-relation shows us to be the exciting instruments of our magnetic disturbances, must—since they overtake the Earth in its orbit—strike it first on the sunset arc and move across the sun-lit face to the sunrise arc. Over and above any *general* effect upon the Earth's magnetism as a whole, we may therefore naturally expect that disturbances thus excited will show certain *local* peculiarities dependent upon the presentation of the several observing stations towards the Sun at the moment when the solar stream overtakes the Earth. This presentation varies with the hours of the local day and with the season of the year, and therefore some kind of a diurnal inequality, some kind of an annual inequality, might naturally be expected in the disturbances recorded at any given station. Inequalities with daily and with annual periods do exist, not only in the diurnal range, but also in the disturbances. Table XIV., given above, illustrates the diurnal inequality in disturbances at Greenwich; Table XIX., which follows later, shows that there is an evident annual inequality. Whether these two inequalities here illustrated are those which should be looked for as a consequence of the action of the solar stream-lines is a point which I wish at present to reserve.

My present purpose is to call attention to two points: *first*, that local peculiarities, both diurnal and annual, are to be expected in the record of magnetic disturbances at any given station as a consequence of the solar excitation; and *second*, that

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though the local peculiarities which have been observed with these daily and yearly periods tend to blur the evidence for the "Interval-Relation," they by no means efface it, for the whole of the evidence for that relation presented in my two former papers is evidence which is still outstanding after these and possibly other effects have done their utmost to impair or conceal it. I now offer a short catalogue of disturbances observed at a distance from Greenwich as an example of the manner in which the relation still comes out, even when no precise points of the disturbances are taken to work upon.

8. *Comparison of Greenwich and Toronto Records.*

Magnetic observatories seldom publish in their results any information about magnetic disturbances, or if they give such information it is usually not in a form convenient for comparing the observations made at different stations. But a short catalogue published in 1875 by the Director of the Toronto Observatory came under my notice, and seemed very suitable for my purpose. It is found on p. 55 of a volume of *Abstracts and Results of Magnetical and Meteorological Observations at the Magnetic Observatory, Toronto, Canada, from* 1841 *to* 1871 *inclusive*, and is headed "Dates (Astronomical Time) at which unusually large Disturbances of Declination occurred at the Ordinary Observation Hours, with the Amount of Abnormal Variation of each such Disturbance. Declination, Abnormal Variation not less than 15′. The + sign indicates an Easterly Disturbance, and — a Westerly Disturbance."

In Table XVII. the second and third columns are reproduced exactly from this catalogue; the third and fourth columns contain the number of the rotation and the longitude of the Sun's centre; the last four columns are derived from Table IX., and give the Greenwich disturbances for the same nine years. The first column gives a reference number for the Toronto disturbance. When two or more succeeding observations appeared to be made during the course of the same storm, a number is only given to the first, and the longitude of the Sun's centre is calculated for the time of that observation alone.

It will be observed that this is not a list of the times of the commencements of the disturbances, but of cases when, at the ordinary times of observation—2^h, 4^h, 10^h, 12^h, 18^h, and 20^h Toronto astronomical time—the declination magnet was found to be displaced from its normal position for the day and hour by more than 15′. A comparison shows that the times given fall on the average about nine hours later in absolute time than those given in Table IX., but a diurnal inequality is distinctly brought out, the numbers for the different hours running as under :—

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TABLE XVI.

Toronto Civil Time.	Disturbances of Declination.		
h	Easterly.	Westerly.	Total.
0	25	12	37
6	2	31	33
8	0	26	26
14	4	0	4
16	4	1	5
22	44	4	48
Total	79	74	153

Table XVIII. shows that, though this diurnal inequality is clearly brought out, and though the times given are not those of the commencements of the disturbances, nor of any specific phase, and are, further, limited to six points of the day, yet that the Interval-Relation shows itself. It will be seen also from Table XVIII. that sometimes a sequence appears in the Toronto catalogue which would have been missed in the Greenwich list, some disturbances strongly marked at Toronto being only feebly felt at Greenwich. This seems to have been the case in the greatest of all the abnormal variations at Toronto, No. 75. On the other hand the longest and most complete sequence at Greenwich—No. liii. of Table X.—comes out only imperfectly in the Toronto list. If the disturbances of the two catalogues, Greenwich and Toronto, are plotted down together in diagrammatic form, as was done in Plate I. of my first paper, the Interval-Relation comes out in a much more striking manner than could be inferred from a consideration of the disturbances registered at either observatory separately. It is not merely that the two observatories supplement each other's records, but the combination of the two catalogues emphasises the solar longitudes to which no disturbances correspond. Sequence No. liii. is seen to be of no exceptional length. It is clear, therefore, that a complete inquiry into the Interval-Relation can only be made from a comparison of the registers of several widely distributed magnetic observatories. Is it too much to ask that such observatories should publish in their annual volumes a few leading details concerning the principal disturbances observed during the year; the times when they began, ended, and attained their greatest intensity, and the degree and character of the chief movements? A simple list, too, of the times when the sharp characteristic movement was observed—which often ushers in great storms, but also occurs at other times—would be of great value.

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Table XVII.

Comparison of Magnetic Disturbances, 1863 *to* 1871, *as observed at Toronto and at Greenwich.*

Toronto. Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Greenwich. Ref. No. Table IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
		d	h	′		°			d	h		°
							196	1863. Jan.	8	4	123	108·1
							197		10	10	...	78·5
1	1863. Jan.	12	18	− 25·8	123	44·9	198		12	3	...	56·0
2		24	12	+ 36·1	124	250·2	199		24	7	124	255·8
...		25	20	− 24·3	...	..						
							200		29	4	...	191·6
							201		31	2	...	166·4
3	Feb.	6	20	− 20·7	...	74·6	202	Feb.	6	15	...	80·2
							203		22	8	125	233·4
4		25	18	− 24·8	125	185·5	204		25	5	...	195·5
							205	Mar.	21	6	126	238·7
5	Apr.	8	10	+ 16·5	127	356·2	206	Apr.	8	5	...	1·8
							207		15	6	127	268·9
6	May	5	10	+ 27·1	128	359·5						
7	July	6	10	+ 19·1	130	259·1						
8		15	10	+ 27·4	...	140·0	208	July	15	9	130	143·5
							209	Aug.	13	10	131	119·4
							210		28	2	132	285·5
9	Sept.	9	20	− 33·8	132	114·2	211	Sept.	9	6	...	124·8
...		10	12	− 20·0	...	...						
							212		23	6	133	300·0
10	Oct.	8	10	+ 38·4	133	97·0	213	Oct.	7	8	...	114·2
11	Nov.	5	12	+ 15·9	134	86·6	214	Nov.	5	7	134	92·3
12		14	10	+ 28·4	135	329·0	215		14	1	135	336·9
13	Dec.	11	20	− 18·6	...	327·7						
							216	1864. Feb.	1	6	137	13·5
							217		11	8	138	240·7
							218	Mar.	6	6	139	285·7
							219		10	3	...	234·6
14	1864. Mar.	31	12	+ 20·5	140	319·9						
							220	Apr.	27	6	141	319·6
15	Apr.	29	10	+ 23·5	141	287·1						
16	May	5	12	+ 15·9	...	207·6	221	May	5	6	...	213·9
							222		25	6	142	309·3

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Toronto.							Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table IX.	Date. G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1864.	d	h	′		°		1864.	d	h		°
17	June	7	12	+ 34·2	142	131·1	223	June	7	4	...	138·4
18		8	18	− 23·6	...	114·5						
							224		22	16	143	293·2
19	July	19	10	− 35·9	144	296·3	225	July	18	15	144	309·7
							226	Aug.	13	7	145	330·2
20	Aug.	24	10	− 26·9	145	180·3						
							227	Sept.	16	19	146	234·5
							228		20	10	...	186·6
21	Sept.	23	4	+ 16·8	146	147·4	229		22	7	...	161·9
22	Oct.	12	20	− 22·1	147	247·9	230	Oct.	13	5	147	245·9
...		14	12	− 23·8	...	...						
...		14	20	− 15·6	...	...						
							231		19	3	...	167·9
							232	Nov.	11	2	148	225·1
23	Nov.	15	10	+ 23·8	148	165·1	233		15	1	...	173·0
24	Dec.	7	10	+ 16·1	149	235·2						
25		11	20	− 16·7	...	176·9	234	Dec.	12	2	149	176·6
							235		15	1	...	137·6
							236		23	3	...	31·1
							237	1865. Jan.	11	5	150	139·8
							238		16	4	...	74·5
							239		25	2	151	317·1
							240	Feb.	15	6	...	38·4
							241		16	23	...	15·9
							242		21	2	152	321·6
							243	Mar.	15	7	...	29·0
26	1865. Mar.	20	12	− 17·2	153	317·4	244		20	3	153	325·3
27	Apr.	15	10	+ 22·7	154	335·5	245	Apr.	16	6	154	327·4
							246	May	13	7	155	330·0
28	June	5	12	+ 17·9	155	20·0						
29		9	10	+ 24·6	156	328·2	247	June	9	11	156	330·6
30		15	10	− 21·5	...	248·8						
31	July	18	4	+ 15·9	157	175·3						
32	Aug.	2	2	+ 22·0	158	338·0	248	Aug.	2	6	158	338·7
...		2	18	+ 28·9	...	...						
...		2	20	− 63·4	...	...						

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Toronto.							Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1865.	d	h	′		°		1865.	d	h		°
...	Aug.	3	2	+ 33·2	...	...						
...		4	18	− 38·8	...	...						
							249	Aug.	10	6	...	232·9
33		11	18	− 21·5	...	210·2						
							250		14	7	...	179·5
34	Sept	20	12	− 16·2	159	35·1						
							251	Oct.	4	17	160	220·5
35	Oct.	12	20	− 17·5	160	110·4						
36		13	18	− 26·6	...	98·3						
...		13	20	− 31·9	...	...						
37		18	20	− 15·5	...	31·3	252		19	0	...	32·0
							253		26	3	161	298·0
38		30	18	− 22·2	161	234·1	254		29	23	...	247·5
...		30	20	− 22·0	...	...						
...		31	12	+ 15·4	...	...						
...		31	18	− 42·8	...	...						
...		31	20	− 20·5	...	...						
							255	Nov.	3	5	...	191·4
39	1866. Jan.	10	10	+ 20·4	163	9·7						
40		27	10	+ 15·9	164	145·9						
41	Feb.	7	10	+ 29·2	...	1·1	256	1866. Feb.	6	3	164	21·0
42		20	12	− 54·7	165	188·8	257		20	13	165	191·1
							258		23	6	...	155·5
43	Mar.	7	10	+ 15·4	166	352·3	259	Mar.	6	8	...	9·5
44		18	18	− 20·2	...	202·9	260		18	7	166	211·9
45	Apr.	3	18	− 15·0	167	351·9						
46		17	10	+ 17·4	...	171·5						
47	May	12	12	+ 17·4	168	200·0						
48	June	15	18	− 15·4	169	106·8						
49	Aug.	9	10	+ 15·5	171	103·5						
50		23	10	+ 15·5	172	278·4	261	Aug.	23	4	172	284·6
51		29	18	− 20·2	...	194·7						
							262	Sept.	9	5	...	59·5
52	Sept.	17	18	− 27·5	173	303·8						
53	Oct.	3	10	+ 25·7	...	97·1	263	Oct.	4	4	173	90·1
54		5	18	− 15·9	...	66·3	264		6	3	...	64·3

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Toronto.							Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1866.	d	h	′		°		1866.	d	h		°
55	Oct.	7	18	− 18·9	...	39·9						
56		9	12	+ 22·7	...	16·8						
57		10	18	− 33·6	...	0·3						
58		11	18	− 20·2	174	347·1	265	Oct.	12	6	174	343·5
59		13	10	+ 29·3	...	325·1						
60		18	10	+ 27·0	...	259·2						
61		30	12	+ 16·2	...	99·8						
62	Nov.	1	10	+ 37·4	...	74·6						
63		25	20	− 18·2	175	112·7	266	Nov.	26	3	175	111·7
							267	1867. Feb.	8	6	178	215·5
							268		13	6	...	149·6
							269	Mar.	6	5	179	233·5
							270		10	6	...	180·3
	1867.						271	May	28	7	182	216·4
64	June	1	10	+ 18·8	182	158·9	272	June	1	11	...	161·3
65	Aug.	31	10	+ 16·6	185	35·2						
							273	Sept.	7	1	186	310·6
66	Sept.	17	10	+ 17·0	186	170·7						
67		21	12	− 15·7	...	116·8						
68		25	12	+ 16·1	...	64·0	274		25	4	...	71·3
69	Oct.	2	12	+ 15·0	187	331·6	275	Oct.	2	7	187	337·3
70		29	18	− 15·6	188	332·2						
							276	1868. Feb.	20	5	192	280·4
							277	Mar.	19	15	193	266·0
							278		30	9	...	124·2
71	1868. Apr.	1	12	+ 37·4	193	93·3	279	Apr.	1	10	...	97·3
...		1	20	− 21·2	...	...						
72		18	12	+ 16·5	194	228·9	280		18	11	194	232·3
							281		27	6	...	116·2
							282		29	5	...	90·3
73	May	20	10	+ 15·8	195	166·9						
74		23	12	+ 22·7	...	126·1						
75	June	10	10	+ 131·3	196	249·0						
76		29	12	+ 19·8	197	356·4	283	June	29	12	197	359·4
77	July	10	10	+ 17·4	...	212·0	284	July	10	2	...	219·3
...		10	12	− 37·0	...	...						

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Toronto.								Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1866.	d	h	′		°		1868.	d	h		°
							285	July	14	13	...	160·3
78	Aug.	4	10	+ 20·4	198	241·2						
							286	Aug.	30	6	199	262·7
79	Sept.	15	12	− 20·9	199	45·2	287	Sept.	15	13	...	47·6
...		15	18	− 41·7	...	...						
...		15	20	− 17·7	...	...						
80		26	10	+ 44·4	200	261·1	288		27	5	200	253·6
...		26	12	+ 21·9	...	...						
81		30	12	− 69·9	...	207·2	289		30	6	...	213·5
...		30	18	− 28·2	...	...						
							290	Oct.	19	4	201	323·9
82	Oct.	22	12	+ 42·8	201	277·0	291		22	3	...	284·9
...		22	18	− 40·1	...	...						
83		23	18	− 33·2	...	260·5	292		24	3	...	258·5
...		25	18	− 18·8	...	...						
...		25	20	− 16·8	...	...						
84	Nov.	19	10	+ 24·4	202	268·9	293	Nov.	19	4	202	275·1
	1869.							1869.				
85	Jan.	19	20	− 15·2	204	179·9	294	Jan.	20	12	204	174·0
86	Feb.	3	10	+ 20·7	205	346·9	295	Feb.	2	11	...	3·4
87		23	10	+ 33·0	...	84·5						
							296	Mar.	9	7	206	264·6
							297		18	1	..	149·3
							298	Apr.	2	5	207	309·3
88	Apr.	5	12	− 22·8	207	262·9						
...		6	4	+ 21·8	...	...						
							299		8	5	...	230·1
89		15	2	+ 20·1	...	136·4	300		14	23	...	141·0
90	May	7	10	+ 18·8	208	201·4						
...		8	12	+ 16·3	...	...						
91		13	2	+ 31·3	...	126·4	301	May	13	2	208	129·3
...		13	4	+ 24·1	...	...						
							302		30	18	209	255·6
							303	June	6	14	...	165·2
92	June	15	18	− 16·3	209	41·0						
93		24	4	− 23·6	210	289·7						
							304		29	7	210	224·6
							305	July	3	10	...	169·9
							306		18	9	211	332·1

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Toronto.							Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table. IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1869.	d	h	′		°		1869.	d	h		°
94	Aug.	6	10	+ 19·9	211	77·3	307	Aug.	6	8	...	81·3
95		15	18	− 22·4	212	313·9						
							308		20	10	212	255·1
96		24	10	+ 33·5	...	199·3	309		24	5	...	205·0
							310	Sept.	2	9	...	83·9
							311		5	7	...	45·4
							312		9	11	213	350·4
							313		11	9	...	325·1
							314		13	11	...	297·5
97	Sept.	27	18	− 16·3	213	106·0	315		27	6	...	115·5
							316	Oct.	5	22	...	1·1
							317		25	1	214	108·9
98	Dec.	13	20	− 18·7	216	179·6						
							318	1870. Jan.	2	14	217	272·4
99	1870. Jan.	8	10	+ 15·8	217	192·6						
100		26	12	+ 21·8	218	314·5						
							319		29	10	218	279·0
101	Feb.	1	12	+ 20·2	...	235·5	320		31	23	...	245·6
							321	Feb.	11	7	...	109·5
							322		22	9	219	323·6
							323	Mar.	21	12	220	326·2
102	Mar.	30	10	+ 17·6	220	205·6						
103	Apr.	4	18	− 16·7	...	135·3	324	Apr.	4	18	...	138·2
							325		11	20	...	44·7
							326		15	12	221	356·3
							327		21	4	...	281·4
							328	May	14	15	222	331·4
							329		19	23	...	260·9
							330	June	12	5	223	313·2
104	June	14	10	+ 17·3	223	281·0						
							331		16	18	...	253·1
105	Aug.	2	18	− 23·5	225	348·2						
106		19	10	+ 36·5	...	127·8	332	Aug.	19	11	225	130·2
							333	Sept.	3	4	226	295·9
							334		7	6	...	242·0
107	Sept.	23	18	− 20·3	226	21·2	335		23	15	...	25·8
							336	Oct.	1	3	227	286·8
							337		14	4	...	114·7

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Toronto.							Greenwich.					
Ref. No.	Date Toronto Mean Time.			Amount.	No. of Rotation.	Long. of Sun's Centre.	Ref. No. Table IX.	Date G.M.T.			No. of Rotation.	Long. of Sun's Centre.
	1870.	d	h	′		°		1870.	d	h		°
108	Oct.	23	18	+ 15·5	228	345·4	338	Oct.	23	22	228	346·1
...		24	12	− 22·8	...	...						
...		24	20	− 21·6	...	...						
109	Nov.	8	10	+ 23·0	...	138·8	339	Nov.	7	19	...	150·0
...		8	18	− 16·2	...							
110		18	20	− 22·7	...	1·5	340		19	3	...	0·7
111	Dec.	15	20	− 17·5	229	5·7	341	Dec.	15	16	229	10·8
...		16	20	− 17·6	...	...						
							342	1871. Jan.	4	5	230	113·4
							343		12	22	231	358·7
112	1871. Feb.	11	12	+ 16·7	232	326·3	344	Feb.	10	11	232	342·9
							345		26	4	...	136·1
							346	Mar.	1	6	...	95·4
							347		22	8	233	177·6
113	Mar.	26	20	− 15·7	233	115·3	348		27	2	...	115·0
							349	Apr.	1	8	...	45·7
114	Apr.	4	10	+ 16·9	...	2·1						
							350		9	5	234	301·8
							351		13	9	...	246·8
115		17	10	− 15·5	234	190·5	352		17	7	...	195·1
116		23	18	− 24·9	...	106·8						
117		27	20	− 20·2	...	52·9	353		28	1	...	53·0
...		28	20	− 18·5	...	...						
118	May	24	12	+ 15·8	235	60·3						
119		26	10	+ 19·0	...	34·9						
120	June	17	12	− 16·7	236	102·7	354	June	17	12	236	105·6
121	July	3	12	+ 15·0	237	250·8						
122		21	12	+ 15·7	...	12·7	355	July	21	13	237	15·0
							356	Aug.	6	1	238	170·0
123	Aug.	12	10	+ 23·1	238	82·8						
							357		21	9	239	327·3
							358		24	8	...	288·2
							359	Sept.	7	8	...	103·3
							360	Oct.	14	5	241	336·6
							361	Nov.	1	6	...	98·7
							362		9	7	242	352·7
							363		19	19	...	214·2

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Table XVIII.

Sequences of the Toronto Disturbances.

Ref. No.	No. of Rotation.	Long.
5	126	356°·2
6*	127	359·5
9	132	114·2
10	133	97·0
11	134	86·6
12	135	329·0
13*	136	327·7
23	148	165·1
25	149	176·9
26	153	317·4
27	154	335·5
...	155	...†
29	156	328·2
...	157	...
32	158	338·0
34*	159	35·1
37	160	31·3
39*	164	369°·7
41	165	361·1
43	166	352·3
45*	167	351·9
48*	169	106·8
...	170	...
49*	171	103·5
...	172	...
53	173	97·1
61*	174	99·8
63	175	112·7
54*	173	66·3
62*	174	74·6
69	186	331·6
70*	187	332·2
75*	196	249·0
...	197	...
78*	198	241·2
80	200	261°·1
83	201	260·5
84	202	268·9
89	207	136·4
91	208	126·4
98*	216	179·6
99*	217	192·6
110	228	1·5
111	229	5·7
113	233	115·3
116*	234	106·8
...	235	...
120	236	102·7
117	234	52·9
118*	235	60·3

9. *The Annual Inequality in Magnetic Disturbances.*

I am indebted to Mr. W. Ellis, not only for the list of disturbances which I utilised in my second paper, but for a complete magnetic calendar, extending from 1848 to 1902, in which every day was classified as a day of "great," "active," "moderate," or "minor" disturbances or of "none." Mr. Ellis has used the first fifty of these fifty-five years in his paper appearing in the *Monthly Notices* for March, vol. lxv. p. 520. I may perhaps be permitted to give the figures for the entire fifty-five years in a slightly different form. I have taken the sums of the numbers of disturbances for fifteen-day periods, so arranged that the dates when the apparent centre of the Sun's disc has the least and greatest latitudes and the dates of the terrestrial equinoxes and solstices fall respectively in the middle of one or other of these periods. Five days have therefore been struck out of the year as well as February 29. It will be seen that

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* Not in the Greenwich catalogue of disturbances, given in Table IX.

† This gap is filled by disturbance No. 246 of Table IX.

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the figures bear out Mr. Ellis's statement that "the spring maximum appears on the whole to fall somewhat before the equinox, and the autumn maximum somewhat after the equinox." It also appears that the summer minimum in like manner falls before the solstice, and the winter minimum decidedly after. The summer minimum is very sharply marked, and coincides with the period when the Sun's equator is on the centre of the disc, and the direction of rotation makes the greatest angle with the ecliptic. The table as a whole suggests that this strongly marked annual inequality is not due to a single cause alone, but to a combination of two or more, inasmuch as the curve is not symmetrical about either the equinoxes or the dates when the Sun's equator is on the centre of the disc. It will be necessary to obtain similar figures from observatories having seasons differing markedly from those at Greenwich, and especially from observatories in the southern hemisphere, before a satisfactory interpretation can be placed upon the peculiarities shown by this annual inequality.

TABLE XIX.

Annual Distribution of Magnetic Disturbances.

From.	To.	Great.	Active.	Moderate.	Total.	
Dec. 30	Jan. 13	0	8	124	132	
Jan. 14	„ 28	0	19	178	197	
„ 29	Feb. 12	5	11	194	210	
Feb. 13	„ 27	8	30	197	235	
„ 28	Mar. 14	3	14	191	208	Hel. lat. of Earth −7°·2
Mar. 15	„ 29	3	15	199	217	Spring equinox
„ 30	Apr. 13	3	18	197	218	
Apr. 14	„ 28	4	18	149	171	
„ 29	May 13	2	8	162	170	
May 15	„ 29	2	8	125	135	
„ 30	June 13	0	9	99	108	Hel. lat. of Earth 0°
June 14	„ 28	1	8	113	122	Summer solstice
„ 30	July 14	4	13	129	146	
July 15	„ 29	2	7	135	144	
„ 31	Aug. 14	8	17	133	158	
Aug. 16	„ 30	3	5	142	150	
„ 31	Sept. 14	7	16	181	204	Hel. lat. of Earth + 7°·
Sept. 16	„ 30	3	10	195	208	Autumn equinox
Oct. 1	Oct. 15	5	18	181	204	
„ 16	„ 30	4	17	199	220	
„ 31	Nov. 14	3	15	165	183	
Nov. 15	„ 29	5	9	156	170	
„ 30	Dec. 14	1	7	145	153	Hel. lat. of Earth 0°
Dec. 15	„ 29	1	7	141	149	Winter solstice

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Determination of Longitude on the Planet Jupiter.
By G. W. Hough.

In the *Monthly Notices*, vol. lxiv. pp. 824–834, I published an article on longitude determinations on the planet *Jupiter*.

It would appear from a paper by Mr. A. S. Williams in *Monthly Notices*, vol. lxv. pp. 167–181, on the same subject that I failed to make clear some points in the discussion. Some further explanation may, therefore, be desirable.

The eye-estimate method has been used by many distinguished astronomers in the past in determining the rotation period of *Jupiter* and *Saturn*, and in common with everybody I imagined that it was a fairly reliable method. I had very little faith in Schmidt's variable error, and also supposed there was a *real* personal equation between different observers. The comparison of eye-estimates with the micrometer measures, however, has shown such grave errors that astronomers ought clearly to understand that a precision observation cannot be made by this method.

In meridian observations the transit of a star is observed over a group of fixed wires, from five to fifteen in number. Suppose all the wires were removed and the transit observed over an imaginary wire bisecting the field, the latter being analogous to that employed in eye-estimates. How would the two methods compare in point of accuracy in right ascension work?

The observations of the Barnard White Spot on *Saturn* in 1903, the only conspicuous spot on the disc, showed that experienced observers differed nearly twenty minutes on the same night, not once, but repeatedly. I think astronomers would not regard such as precision observations. I have already shown that a micrometer used for a fraction of the time required to secure such crude estimates would furnish observations of precision such as are demanded in other directions. If, therefore, anything I can say will induce observers who have micrometers to use them when we discover another suitable spot for determining the rotation of *Saturn* my time will not be entirely wasted.

In my previous paper I compared the micrometer results with a previously computed ephemeris by Marth to show that there was no variable or cumulative error.

As all the conclusions arrived at are based on the assumption that micrometer work is subject to accidental error only, some further explanation on this point may be desirable.

In the determination of longitude the central meridian of the disc is not directly used. The measures are referred to the limbs of the planet, and every measure for longitude is virtually a measure of the equatorial diameter, the spot or marking serving